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ECOLOGICAL AND BIOCHEMICAL STUDIES ON THE NILE FISH, *OREOCHROMIS NILOTICUS* (L.), CULTURED IN DIFFERENT AQUATIC HABITATS

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ABSTRACT

The aquatic habitat with its water quality is considered the main factor controlling the state of health and disease in both cultured and wild fish. In the present investigation the effect of water quality on the quality of the Nile tilapia, *Oreochromis niloticus*, has been studied. For that purpose the fish were collected from three different aquatic habitats: the River Nile in the vicinity of Cairo at 15 km downstream north of the industrial zone of Helwan, Abbassa freshwater fish farm and the brackish water farm at El-Fayoum. Physico-chemical characteristics of water collected from the different water bodies showed highly significant differences in the dissolved oxygen, pH, salinity, total hardness, total alkalinity, electric conductivity, total phosphorus and nitrate with the highest values in water collected from El-Fayoum brackish water Farm, except for the dissolved oxygen which was slightly higher in the River Nile than that of the farms. Moreover, concentrations of the heavy metals (Fe, Cu, Zn and Mn) were significantly higher in water collected from both fish farms than that collected from the River Nile, except for zinc which was higher in water collected from the River Nile.

Phytoplankton showed the highest density in the freshwater farm at El-Abbassa and the highest zooplankton density was recorded in the brackishwater farm at El-Fayoum. However, water collected from the River Nile in the vicinity of Cairo showed much lower density of both phyto and zooplankton.

Fish collected from the River Nile had lower values of the red blood cell count, haemoglobin content, packed cell volume and serum total lipids but higher white blood cell count and serum; glucose, total protein, AST, ALT, creatinine and uric acid than fish collected from both farms. This indicated that Nile

tilapia from the farms are superior in quality compared with those from the River Nile.

Bioaccumulation of either of the studied heavy metals in gills, liver, kidneys and muscles of fish collected from the River Nile was much higher than that of fish collected from El-Abbassa and El- Fayoum farms respectively and led to clear damage in tissues of those vital organs.

The results also revealed that the meat quality of fish collected from El-Fayoum Farm was more superior than that of fish collected from El-Abbassa Farm and the River Nile which appeared of lower quality.

INTRODUCTION

Fish are important members of aquatic ecosystems and an important source of human food. However, fish distribution data indicate a reduction in the commercially desirable fish species as the river conditions deteriorate. The industrial effluents discharged directly to the river Nile by various industries have been found to cause heavy fish mortality due to hypoxia, high levels of organic substances, inorganic salts and heavy metals (El-Naggar *et al.*, 1998; Haggag *et al.*, 1999; Salah El-Deen *et al.*, 1999).

So, the increasing demand for fish, as a source of protein in Egypt, has motivated the development of aquaculture and intensification of culture methods (Ishak, 1979). Rearing of fish is not only concerned with quantitative growth, but also with improving the quality of the product. Thus, it is necessary to have a sufficient supply of good water quality for pond culture (Boyd,1990).

Addition of different types of fertilizers causes appropriate changes in the physical and chemical features of water which may directly affect fish growth, or indirectly through their qualitative and quantitative effects upon bacterial flora, phytoplankton and zooplankton which in turn affect fish growth and productivity (Shaaban *et al.*, 1999).

The Nile tilapia, *Oreochromis niloticus,* has a wide natural distribution in fresh and brackish water. It is very common in the river Nile and its tributaries, coastal lakes and Lake Nasser (Bishai and Khalil, 1997). Tilapias generally tolerate a wide range of environmental conditions including salinity (Assem, 1994), being adaptable for rearing in fish farms with moderate saline water (Kheir *et al.*, 1998a).

In Egypt, there is a considerable interest in extending the culture of the Nile tilapia, *Oreochromis niloticus,* to brackish and salt water, due to their high marketability, excellent growth rates and good fish quality. Highest percentage of weight gain and highest specific growth rate were recorded at 15 ‰ for the adult and fry *Oreochromis niloticus* reared at

different saline concentrations of 5, 10 & 15 ‰, as well as at fresh water as control that showed the lowest values (Kheir *et al.*, 1998b). Moreover. Woo *et al.*(1997) reported that tilapia (*Oreochromis niloticus*) kept in 15 ppt sea water had higher growth rates than fish kept in 0 ppt (fresh water) or 30 ppt sea water.

Fish culturists are more concerned with those aspects of water quality which regulate the suitability of water for rearing fish. This is because failure to maintain adequate water quality in ponds may critically influence the growth rate, physiological and biochemical status and consequently the meat quality of fish(Ahmed *et al.*, 1992;Shenouda *et al.*, 1992;Salah El-Deen and Khattab,1993;Assem,1994;Kheir *et al.*, 1998a; El-Naggar *et al.*,1998; Haggag *et al.*,1999 and Salah El-Deen *et al.*,1999).

The aim of the present investigation is to find out the effect of water quality of fish farms, either freshwater or brackish-water, on the meat quality of the Nile tilapia, *Oreochromis niloticus,* as compared with that obtained from the River Nile. For that purpose investigation of various biochemical parameters was undertaken as an indication of the superiority in meat quality of Nile tilapia either obtained from natural resources i.e. the river Nile, or that cultured in either freshwater or brackish water fish farms.

MATERIALS AND METHODS

Fingerlings of the Nile tilapia, *Oreochromis niloticus,* with an average total length of 4.5 ± 0.5 cm and average weight 2.5 ± 0.1 g, were collected from El-Abbassa Farm, El-Sharkia Governorate, during April, 1999. The fingerlings were cultured in earthen ponds of El-Abbassa (fed with fresh water from Ismailyia Canal water) and El-Fayoum (fed with brackish drainage water) fish farms with the same stocking density ($5/m^3$) and using the same artificial feed (28 % protein).

Water and fish samples were collected from both fish farms (El-Abbassa and El-Fayoum) and the river Nile (Cairo sector, 15 km downstream to the north, where the major industrial effluents dischrge from Helwan industrial area) every 15 days for a period of 105 days (from May 5 till August 18, 1999) for the following investigations:

(1) Water analyses

Water samples collected from the fish farms and the river Nile were analyzed for pH, dissolved oxygen, total hardness, total alkalinity, nitrate, salinity, total phosphorus and electric conductivity according to the method mentioned by American Public Health Association standard methods (APHA, 1985). Heavy metal concentrations in water were determined by atomic absorption spectrophotometry (Perkin Elmer, 2280; APHA,1985). Metals examined in this study were copper, zinc, iron and manganese.

(2) Plankton estimation

(a) Phytoplankton

Phytoplankton density (org./l) was estimated according to the methods reported in APHA (1985). The phytoplankton organisms were quantitatively counted after fixing and preserving the water sample (one liter) by Lugol's solution at a ratio of 0.3 ml Lugol's solution to 100 ml sample.

(b) Zooplankton

Zooplankton organisms were counted according to APHA(1985). Representative samples, each of 10 litre were collected and filtered throughout a plankton net (55 micron mesh diameter). The residue was transferred to 50ml water filtrate in a glass bottle and preserved with a few drops of 4 % formalin solution.

(3) Growth parameters

Body weights were recorded to the nearest gram and total body lengths were measured to the nearest 0.1 cm for the fish collected from the two farms, to adjust the artificial feed rate, till reaching a size of approximately 150 g compared with that collected from the river Nile . All the following measurements were carried out on fish, either collected from the farms or the river Nile, of approximately the same size (150 g).

(a) Condition factor (k): k factor was calculated for individual fish from the formula recommended by Schreck and Moyle (1990):

$$k = \frac{W}{L^3} \times 100$$

Where

W: is the wet weight in g.

L : is the total length in cm.

(b) Hepatosomatic index (HSI) was calculated according to Schreck and Moyle (1990) as follows:

$$HSI = \frac{\text{Weight of the liver}}{\text{total fish weight}} \times 100$$

(4) Blood sampling and examination

Blood samples were withdrawn from the arteria caudalis using sodium citrate as anticoagulant and examined for the following:

. Total number of erythrocytes (RBCs) and leukocytes (WBCs) were counted using improved Neubauer Haemocytometer.

. Haemoglobin content was estimated using cyanmethemoglobin method described by Van Kampen and Zijlstra (1961).

. Packed cell volume (PCV) was carried out in small haematocrit tubes using haematocrit centrifuge at 3000 r.p.m. for 15 minutes.

. Blood indices

Blood indices were calculated according to Gupta (1977) as follows:

(a) Mean corpuscular volume (μm^3/cell)

$$MCV = \frac{\text{P.C.V. (\%)}}{\text{R.B.Cs (million/mm}^3\text{)}} \times 10$$

(b) Mean corpuscular haemoglobin (pg/cell)

$$MCH = \frac{\text{Hb (gm/100 ml blood)}}{\text{R.B.Cs (million/mm}^3\text{)}} \times 10$$

(c) Mean corpuscular haemoglobin concentration (g/100 ml)

$$MCHC = \frac{\text{Hb (gm/100 ml blood)}}{\text{P.C.V.}} \times 100$$

(5) Biochemical analyses

(a) Serum analyses

Blood samples were centrifuged to get serum for the following analyses:

- The level of serum glucose was measured using the GOD - PAP method (enzymatic colorimetric method) according to Trinder (1969) using Boehringer Mannheim kits.
- Total protein content was determined by Biuret test (King and Wootton, 1959)
- Total lipids level was determined colorimetrically by sulphova-nillin reaction according to Schmit (1964).
- Serum aspartate amino transferase (AST, E.N. 2.6.1.1) and alanine amino transferase (ALT, E.N. 2.6.1.2) activities were determined colorimetrically using transaminases kits according to the method described by Reitmans and Frankel (1957).
- Creatinine was measured using colorimetric method described by Henry (1974).
- Uric acid was measured using enzymatic reaction according to Barham and Trinder (1972).
- Serum electrolytes (Na^+, K^+, Ca^{++} & Mg^{++}) were measured using atomic absorption spectrophotometry (Perkin Elmer, 2280) according to Fernandez and Khan (1971) method.

(b) Meat quality

- Muscle and liver water content was determined according to Sidwell *et al.* (1970).
- Total muscle protein was determined using the semi-microkjeldahl

method as reported by Josyln (1950)

- Total lipids of muscles was determined by the standard method reported in A.O.A.C. (1970).
- Muscle ash was determined by burning the samples in a muffle furnace for 16 hours at 550°C (Sidwell *et al.*, 1970)

(6) Heavy metal concentrations

Residual heavy metals (Cu, Zn, Fe and Mn) were determined in the gills, liver, kidneys and muscles of the Nile tilapia according to American Public Health Association, APHA (1985) then measured using atomic absorption spectrophotometry (Perkin Elmer, 2280).

(7) Histological studies

Gills, liver and kidneys of the Nile tilapia collected from the fish farms and the River Nile were preserved in Bouin's fixative. Tissues were processed, sectioned at 5µm and then stained using haematoxylin and eosin (Carleton *et al.*, 1967).

(8) Statistical analyses

The results were statistically analyzed using t-test, analyses of variance (F-test) and Duncan's multiple range test to determine difference in means (Duncan, 1955).

RESULTS AND DISCUSSION

The water quality of the aquatic habitat is considered the main factor controlling the state of health and disease in both cultured and wild fish. Nowadays, deterioration of the river Nile conditions by the action of effluents from various industries affect the quality and quantity of the Nile fish (El-Naggar *et al.*, 1998; Haggag *et al.*, 1999 and Salah El-Deen *et al.*, 1999). So, the increasing demand for fish, as a source of protein, in Egypt has motivated the development of aquaculture and intensification of culture methods (Ishak, 1979).

Traditionally, tilapias are cultured in fresh water or cages in inland waters (Ishak, 1979). However, in Egypt, there is a considerable interest in extending the culture of the Nile tilapia, *Oreochromis niloticus,* to brackish and salt water which gives a good quality fish with a high marketability and excellent growth rates (Kheir *et al.*, 1998b). Physicochemical properties of water from the locations of the different aquatic habitats environmental systems (river Nile; El-Abbassa freshwater farm and El-Fayoum brackish-water farm) are illustrated in Table 1. The data show highly significant differences in the different water quality parameters among the different locations.

The highest value of dissolved oxygen was recorded in the river Nile followed by El-Fayoum and El-Abbassa fish farms. This may be attributed to the virtual mixing and water current of the river Nile (Mikhail, 1979 and Amer, 1995).

The present data also showed high values of pH, total alkalinity, salinity, total hardness and electrical conductivity in water of El-Fayoum Farm followed by that of El-Abbassa Farm and the lowest values were recorded at the river Nile. This is attributed to the quality of agricultural drainage water which is rich in fertilizers and chemicals (brackish water) supplying El-Fayoum Farm. Moreover, the high pH and alkalinity values of water from El-Fayoum and El-Abbassa Farms could be related to the increase in phytoplankton density (Table,2) which leads to an increase in photosynthesis that involves the uptake of free carbon dioxide from water and precipitation of calcium carbonate (Boyd, 1990 ; Saeed, 1999). However, the high total hardness of El-Fayoum Farm may be related to the high contents of salts in the brackish water that feeds the farm.

The highest total phosphorus concentration was recorded in El-Abbassa Farm followed by El-Fayoum Farm but the highest nitrate value was observed in water of El-Fayoum Farm followed by El-Abbassa Farm and the lowest values were recorded at the river Nile. The very low total phosphorus in the river Nile may be attributed to the lack of phosphorus source in water as previously reported by Elewa and Mahdi (1988). However, the high density of phytoplankton community in water of the farms (higher in water of El-Abbassa Farm than that of El-Fayoum Farm, Table 2) may consume the soluble orthophosphate and hold it in their cells, thus increasing of total phosphorus (Qin and Culver, 1996).

Comparing the average concentrations of heavy metals (Fe^{++}, Cu^{++}, Zn^{++} and Mn^{++}) in water from the different locations, the results revealed the presence of metals as follows (Table 1):

Iron (Fe^{++}) : El-Abbassa Farm > El-Fayoum Farm > river Nile.
Copper (Cu^{++}) : El-Fayoum Farm > El-Abbassa Farm > river Nile.
Zinc (Zn^{++}) : river Nile > El-Abbassa Farm > El-Fayoum Farm .
Manganese (Mn^{++}) : El-Fayoum Farm > El-Abbassa Farm > river Nile.

The high copper and manganese concentrations in water of El-Fayoum Farm could be attributed to the quality of the agricultural drainage water, which is rich in fertilizers and chemicals, that feeds the farm as shown by Elsikhry (1990), Nagdi and Shaker (1998) and Saeed (1999). However, the high iron in water of El-Abbassa Farm fed with Ismailyia canal water and zinc in water of the sampling site of the river Nile could be attributed to the industrial effluents discharged directly to the river Nile and its branches as previously reported by El-Naggar *et al.* (1998), Haggag *et al.* (1999) and Salah El-Deen *et al.* (1999).

The low concentrations of heavy metals in water collected from the river Nile in presence of the industrial effluents discharged directly to it may be due to the virtual mixing and water current of the Nile, adsorption on sediments and/or its accumulation in fish (Figs 1 and 2) as previously reported by Haggag *et al.* (1999) and Salah El-Deen *et al.* (1999). The high concentration of zinc in water collected from the sampling site of the river Nile than that collected from both fish farms could be attributed to its high concentration in the effluents discharged directly to the river Nile. Furthermore, the site of sampling is 15 km to the north of Helwan industrial area where maximum discharge takes place.

The highest densities of phytoplankton were recorded in water of El-Abbassa Farm followed by that of El-Fayoum Farm and the lowest number were recorded in the river Nile (Table 2). Moreover, the phytoplankton population in El-Abbassa Farm water was dominated by diatoms (Bacillariophyta) followed by green algae (Chlorophyta), whereas blue green algae (Cyanophyta) and euglenoids (Euglinophyta) represent the lowest number. However, the dominant population at El-Fayoum Farm was Cyanophyta followed by Euglinophyta and the lower numbers were Bacillariophyta and Chlorophyta. The present results are in agreement with those of Lathrop (1988), Abdel Mageed (1997), Ibrahim (1997) and Yussof and McNabb (1997) and Shaaban *et al.* (1999) who postulated that the increase in pH, total alkalinity and water nutrients causes high densities of phytoplankton than in natural water of low nutrients content. The dominance of the blue green algae in one of the studied environmental system and other populations in the other environmental systems could be attributed to the water quality variables that control the populations as previously reported by Lathrop (1988), Ibrahim (1997) and Yussof and McNabb (1997).

The present results showed that the highest density values of zooplankton population were recorded in water of El-Fayoum Farm (dominated by rotifers) followed by that of El-Abbassa Farm (dominated by Cladocera) and the lowest density of zooplankton was recorded in water of the river Nile (Table 2). These results coincide with those of Abdel Mageed (1997), Ibrahim (1997) and Shaker (1998) who observed a linear relationship between the total number of both phytoplankton and zooplankton standing crop correlated with the high levels of nutrients (phosphate and nitrate)which act as fertilizers, thus increasing the natural productivity of water.

The values of the condition factor "k"are estimated for comparative purposes to assess the impact of environmental alterations on fish performance (Clark and Fraser, 1983). Therefore, the fluctuation in "k" may reflect the health condition of the fish as well as their protein and lipid contents (Weatherly and Gill, 1983).

The lower values of the condition factor "k" of the Nile tilapia, *Oreochromis niloticus*, collected from the river Nile (Table 3) may be due to the toxic effect of the different heavy metals accumulated at high concentrations in the various tissues of the fish (Clark and Fraser, 1983; Haggag, *et al.*, 1999 and Salah El-Deen *et al.*,1999) and/or the low densities of both phyto and zooplankton recorded in the present study and previously reported by Ibrahim (1997) and Shaker (1998) and Shaaban *et al.*(1999). On the other hand, the high values of "k" of fish collected from El-Fayoum and El-Abbassa Farms are in agreement with the results recorded by Saeed (1999) and Shaaban *et al.*(1999) who attributed that to the high total phosphorus and nitrogen concentrations and the increase in the water productivity accompanied by increase in fish growth.

Fish collected from the brackish water (El-Fayoum Farm) showed higher "k" values than those of fish collected from the freshwater (El-Abbassa Farm). This coincides with the finding obtained by Kheir *et al.* (1998b) who attributed these results to the osmoregulatory factor, increase of food consumption as a result of increased metabolism, minimized oxygen consumption and an increase in growth hormone.

The present study indicates that the hepatosomatic index, which is another biological parameter that helps in studying growth of fish (Weatherly and Gill, 1987), did not change significantly in fish collected from El-Abbassa and El-Fayoum Farms (Table 3). However, there is a significant decrease in hepatosomatic index of fish collected from the river Nile. Such a finding is in agreement with those of Haggag *et al.*(1999) and Salah El-Deen *et al.* (1999) who attributed that to a depletion of liver glycogen followed by hyperglycemia that reflects the fish's need for energy necessary to resist the stress.

Analysis of liver water content (Table 3) showed that there was only slight dehydration in fish collected from the brackish water (El-Fayoum Farm). This finding is in agreement with that recorded by Woo *et al.*(1997) and Kheir *et al.*(1998a)who attributed that to osmoregulation.

Blood parameters

Haematological investigations have been developed for evaluation of fish health conditions (Aldrin *et al.*, 1982). As a matter of fact, blood serves as the most convenient indicator of the general condition of the animal body. Subsequently, haematological studies are promising tools for investigating physiological changes caused by environmental pollutants (El-Naggar *et al.*, 1998 and Haggag *et al.*, 1999).

Regarding blood parameters of fish (Table 4), the present results revealed that there was no significant differences in the studied blood parameters of fish collected from El-Abbassa and El-Fayoum Farms which were in the normal ranges as previously recorded by El-Naggar *et al.*

(1998). However, fish collected from the river Nile showed a decrease in red blood cells count, haemoglobin content and haematocrite values and an increase in WBCs count. These findings coincide with those reported by El-Naggar *et al.*(1998) and Haggag *et al.*(1999) who attributed the decrease in RBCs, Hb and Ht values to the reduction in red blood corpuscles production in the haematopoietic organs under the action of heavy metals accumulated at high concentrations in the various tissues and to intrahepatic and intrasplenic haemorrhage induced by the action of accumulated heavy metals. The decrease in blood parameters (RBCs, Hb and Ht values) is accompanied by an increase in mean corpuscular volume(MCV) and mean corpuscular haemoglobin(MCH) and by non significant change in mean corpuscular haemoglobin concentration (MCHC). This may be due to the haemolytic action that led to fluid loss to the tissues with subsequent decrease in plasma volume (Swift,1981).

The increase in WBCs of fish was suggested to indicate alteration in defense mechanism against the action of the highly toxic heavy metals, discharged directly to the river Nile, to which the fish are exposed during their life in the Nile (El-Naggar *et al.*, 1998 and Haggag *et al.*, 1999).

Serum constituents

Analyses of serum constituents have proved to be useful in the detection and diagnosis of metabolic disturbance and disease (Aldrin *et al.*, 1982).

The present results showed highly significant differences in the serum constituents (Table 5) with the highest values in serum glucose, total protein, AST, ALT, creatinine and uric acid of fish collected from the river Nile followed by that of fish collected from El-Fayoum and El-Abbassa Farms. On the other hand, the lowest value of serum total lipids was recorded in fish collected from the river Nile and the highest value in fish from El-Fayoum Farm.

Blood glucose appeared to be a sensitive and reliable indicator of environmental stress in fish (Nemcsok and Boross, 1982). The reported hyperglycemia may be due to an enhanced glycogen breakdown in liver, probably because of the highly toxic heavy metals in water (Diwan *et al.*,1979) and/or an increase in plasma concentration of catecholamines and corticosteroids as a stress response of fish subjected to environmental alterations (Mazeaud *et al.*, 1977).

In the present study, the increase in the serum total protein in fish may be attributed to several pathological conditions as damage of liver, kidney and gills (Figs. 3, 4 and 5 A)which led to disturbance in these organs (Salah El-Deen *et al.*, 1996). This increase in serum total protein may also be due to haemoconcentration or impaired water balance (Mazeaud *et al.*, 1977).

Fish collected from the river Nile showed a significant decrease in total serum lipid values than fish collected from both farms. The decrease in total serum lipids of fish is atrributed to the increase in the secretion of catecholamines (Pickering, 1981) and corticosteroids (Mazeaud *et al.*, 1977), as a result of pollutant stress which enhanced metabolic rate and in turn reduced metabolic reserves.

The high serum total lipids and total protein of fish collected from El-Fayoum Farm may be attributed to an osmoregulatory factor, increase of food consumption as a result of increased metabolism and minimized oxygen consumption as previously reported by Kheir *et al.* (1998b).

The present investigation also revealed that fish collected from the river Nile showed an elevation in AST and ALT activities as compared with those collected from the farms (Table 5). This elevation is attributed to the damage of liver and kidney cells (Figs 4 and 5 A) by the action of accumulated heavy metals in these vital organs (Figs. 1 and 2) as previously reported by Heath (1987) and Sandnes *et al.* (1988).

Following cell damage, the membranes become permeable and enzyme activities are found in the extracellular fluid and serum. So, determination of transaminases, AST and ALT have proved useful in the diagnosis of liver and kidney diseases in fish (Maita *et al.*, 1984 and Sandnes *et al.*, 1988).

Serum creatinine and uric acid can be used as a rough index of the glomerular filtration rate (Maita *et al.*, 1984). Low values of creatinine and uric acid have no significance but increased values cause several disturbances in the kidney (Maxine and Benjamine, 1985).

In the present investigation, fish collected from the river Nile showed an elevation in serum creatinine and uric acid. This may be attributed to the action of the accumulated heavy metals (Figs. 1 and 2) on the glomerular filtration rate which causes pathological changes of the kidney (Saad *et al.*, 1973 and Oikari and Soivio, 1977).

Serum electrolytes

Osmoregulation is the process by which the total electrolyte content and water volume in an organism are held relatively constant. Serum electrolytes play an important role in the ionic balance of the cell and in osmoregulation in fish. The present study revealed that there was significant differences in serum Na^+, K^+ and Ca^{++} (Table 6) with the highest values in fish collected from the brackish water (El-Fayoum Farm) but non-significant in serum Mg^{++} of fish collected from the different locations. The results are in agreement with the findings of Kheir *et al.* (1998a) who reported an increase in serum electrolyte concentrations of the Nile tilapia, *Oreochromis niloticus*, reared in different saline concentrations.

Meat quality (muscle chemical composition)

Regarding the muscle chemical composition (Table 7), the decrease in total muscle protein and total lipids of fish collected from river Nile may be attributed to the change in water quality by the action of the industrial effluents which are discharged directly to the river Nile and influence the growth rate and the quality of fish (Hodoson *et al.*, 1984).

In the present investigation an increase in muscle water content of fish collected from River Nile was recorded. This finding is in agreement with that of Weatherly and Gill (1987) who reported that depletion of body constituents (total protein and total lipids) results in tissue hydration and an inverse dynamic relationships between protein as well as lipids and water content in the muscle. The increase in muscle ash of fish collected from agricultural drainage water may be attributed to the bioaccumulation of heavy metals in fish as previously reported by Haggag *et al.* (1999).

However, the increase in the total muscle protein and total muscle lipids of fish collected from El-Fayoum and El-Abbassa Farms could be attributed to the water quality. The water in both fish farms is rich in nitrogen, phosphorus and organic matter that cause appropriate changes in the physical and chemical features of water. The latter may affect directly fish growth and consequently its meat quality (Khalil and Hussein, 1996), or indirectly through their qualitative and quantitative effects upon bacterial flora, phytoplankton and zooplankton which in turn affect the fish growth and productivity (Shaaban *et al.*, 1999). In addition to the natural food, cultured fish in both fish farms feed on artificial food containing 28 % protein that could improve the growth and meat quality of fish.

Residual heavy metals

Bioaccumulation of heavy metals does not only depend on the structure of the organ but also on the interaction between metals and the target organs (Sorensen, 1991). The concentrations of the studied heavy metals (Fe, Zn, Cu and Mn) in some selected vital organs (gills, liver, kidneys and muscles) of the Nile tilapia collected from the different locations are shown in Figs 1and 2.

It is clear from the present results that the highest concentrations of the different heavy metals were found in fish collected from the river Nile in the following order: liver tissues > kidneys > gills > muscles. Heavy metals were significantly higher in fish viscera, including liver tissue, than in the edible muscle tissues as previously shown (Shereif and Moaty, 1995 ; Khalil and Hussien, 1996). Moreover, heavy metals increased metallothionein content in tissues, being most effective in the liver (Hilmy *et al.*, 1987). In the present investigation the high concentrations of the various heavy metals in the different organs of the Nile tilapia collected from the river Nile may be attributed to their exposure to high concentration of heavy metals in water further south near the highest effluent discharge.

On the other hand, the highest total hardness (658 ± 47 mg/l as $CaCO_3$) and total alkalinity (329 ± 19 mg/l as $CaCO_3$) of the brackish water (El-Fayoum farm) induced regenerative changes in the tissues of gills (Fig 3 C), liver(Fig 4 C) and kidneys (Fig 5 C) of fish. A possible explanation of the restoration of the studied histological sections and the biochemical parameters, more or less to the normal levels, is that fish in hard water take up less and/or excrete more of the metal than those in the less hard one as previously reported by Miller and Mackay (1979) and Pascoe *et al.*(1986). The mechanisms which may be considered in attempting to explain the modifying effect of water hardness and alkalinity on heavy metals toxicity may be: a) decrease of gill membrane permeability and b) inactivation of absorbed metal by sequestration in granules or binding to protein (metallotheoinin). The highest water hardness and water alkalinity of the brackish water could play a role in inhibiting the toxicity of the recorded heavy metals as previously reported by Miller and Mackay (1979) , Pascoe *et al.*(1986) and Sorensen (1991).

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Table (1). Quality of water collected from different aquatic habitats.

Locations	Dissolved oxygen (mg/l)	pH	Salinity g/l	Total Hardness mg/l as $CaCO_3$	Total alkalinity mg/l as $CaCO_3$	E.C mohs	P mg/l	NO_3 mg/l	Fe mg/l	Cu mg/l	Zn mg/l	Mn mg/l
River Nile	8.05 ± 0.23 A	7.6 ±0.18 B	0.04 ± 0.01 C	149 ± 6.2 C	114 ± 6.4 B	0.34 ± 0.04 B	0.09 ± 0.02 B	0.08 ± 0.2 B	0.37 ± 0.01 C	0.15 ± 0.01 C	0.57 ± 0.08 A	0.02 ± 0.01 C
El-Abbassa Farm	7.43 ± 0.3 B	8.29 ±0.15 A	0.91 ± 0.07 B	201 ± 4.9 B	118 ± 4.9 B	0.34 ± 0.03 B	0.54 ± 0.08 A	0.51 ± 0.09 A	0.89 ± 0.01 A	0.26 ± 0.01 B	0.4 ± 0.01 B	0.09 ± 0.01 B
El-Fayoum Farm	7.03 ± 0.52 C	8.36 ±0.22 A	12.9 ± 1.3 A	658 ± 47 A	329 ± 19 A	13.1 ± 2.2 A	0.52 ± 0.07 A	0.52 ± 0.1 A	0.74 ± 0.04 B	0.31 ± 0.01 A	0.33 ± 0.01 C	0.12 ± 0.02 A
F-value	15.3**	34.9**	703**	802**	796**	262**	130**	88**	983**	319**	57**	169**

Data are represented as means of eight samples + S.D..
Means with the same letter for each parameter are not significantly different, otherwise they do (Duncan's multiple range test, 1955).
** Highly Significant difference ($P<0.05$).

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Table (3): Condition factor, hepatosomatic index and liver water content of the Nile tilapia, *Oreochromis niloticus* Collected from different aquatic habitats.

Locations	Condition factor	Hepatosomatic index	Liver water content (%)
River Nile	1.57 ± 0.08 C	1.15 ± 0.13 B	73.9 ± 0.8 A
El-Abbassa farm	1.85 ± 0.06 B	2.27 ± 0.18 A	73.7 ± 0.6 A
El-Fayoum farm	2.23 ± 0.11 A	2.35 ± 0.22 A	72.9 ± 0.8 B
F-value	117**	115**	4.7**

Data are represented as means of twenty samples ± S.D.
Means with the same letter for each parameter are not significantly different, otherwise they do (Duncan's multiple range test, 1955).
* Significant difference ($p < 0.05$) ** Highly significant difference ($P < 0.01$)

Table(2): Average counts of different components of phytoplankton and zooplankton (org./l) in water collected from different aquatic habitats.

LOCATIONS	PHYTOPLANKTON					ZOOPLANKTON			
	Cyanophyta	Chlorophyta	Bacillariophyta	Euglinophyta	Grand total	Rotifers	Cladocera	Copepoda	Grand total
River Nile	1024 ± 104 C	6831 ±1594 C	3540 ± 791 C	Not Detectable	11395 ± 981 C	14 ± 2 C	32 ± 2 C	3 ± 1 C	50 ± 3 C
El-Abbassa farm	25125 ± 2748 B	55000 ± 8518 A	64125 ± 7491 A	13125 ± 1356 B	157375 ± 16150 A	57 ± 8 B	173 ± 11 A	56 ± 2 A	286 ± 10 B
El-Fayoum farm	48527 ± 3991 A	15062 ± 2347 B	19010 ± 1092 B	34721 ± 9473 A	117321 ± 7360 B	392 ± 57 A	80 ± 6 B	14 ± 2 B	486 ± 53 A
F-value	576**	198**	410**	81**	432**	308**	802**	282**	387**

Data are represented as means of eight samples ± S.D.
Means with the same letter for each parameter are not significantly different, otherwise they do (Duncan's multiple range test, 1955).
** Highly significant difference ($P < 0.01$)

Table (4): Blood parameters of the Nile tilapia; *Oreochromis niloticus*, collected from different aquatic habitats.

Locations	RBCs (X 10^6/mm^3)	Hb (g/100 ml)	Ht (%)	MCV (m^3/cell)	MCH (pg/cell)	MCHC (g/100 ml)	WBCs (X 10^3/mm^3)
River Nile	0.87 ± 0.09 B	3.7 ± 0.89 B	17.6 ± 1.06 B	205 ± 25 A	42.8 ± 10.6 A	20.9 ± 4.8 A	26.7 ± 1.4 A
El-Abbassa Farm	1.43 ± 0.14 A	4.6 ± 0.42 A	23.8 ± 2.37 A	167 ± 16.5 B	32.4 ±4.4 B	19.6 ± 2.9 A	22.9 ± 0.51 B
El-Fayoum Farm	1.42 ± 0.12 A	5.09 ± 0.66 A	24.0 ± 2.14 A	169 ± 10.7 B	35.9 ± 4.9 A/B	21.2 ± 2.3 A	23.3 ±0.74 B
F-value	56.8**	8.4**	27.6**	11.1**	4.2*	0.51	39.1**

Data are represented as means of eight samples + S.D..
Means with the same letter for each parameter are not significantly different, otherwise they do (Duncan's multiple range test, 1955).
* Significant difference (P<0.05). ** Highly Significant difference (P<0.05).

Table (5): Serum constituents of the Nile tilapia; *Oreochromis niloticus*, collected from different aquatic habitats.

Locations	Glucose (mg/100 ml)	Total protein (g/100 ml)	Total lipids (g/l)	AST (u/l)	ALT (u/l)	Creatinine (mg/100 ml)	Uric acid (mg/100 ml)
River Nile	167 ± 31 A	5.33 ± 0.62 A	2.89 ± 0.34 C	27.13 ± 2.74 A	10.41 ± 1.29 A	7.51 ± 0.84 A	33.88 ± 4.42 A
El-Abbassa Farm	52.3 ± 3.3 C	2.45 ± 0.47 C	5.6 ± 0.44 B	15.01 ± 1.02 Ç	4.74 ± 0.29 B	2.48 ± 0.28 C	19.13 ± 1.25 C
El-Fayoum Farm	82.9 ± 5.4 B	3.37 ± 0.53 B	6.34 ± 0.6 A	17.39 ± 1.13 B	4.91 ± 0.36 B	5.12 ± 0.63 B	25.88 ± 1.55 B
F-value	84**	58.4**	118**	100**	132**	128**	55.6**

Data are represented as means of eight samples ± S.D..
Means with the same letter for each parameter are not significantly different, otherwise they do (Duncan's multiple range test, 1955).
** Highly Significant difference (P<0.05).

Table (6): Serum electrolytes of the Nile tilapia; *Oreochromis niloticus*, collected from different aquatic habitats.

Locations	Na (mEq/l)	K (mEq/l)	Ca (mEq/l)	Mg (mEq/l)
River Nile	145 ± 1.7 B	2.9 ± 0.2 B	2.54 ± 0.05 A	1.75 ± 0.04 A
El-Abbassa Farm	146 ± 2.2 B	2.9 ± 0.19 B	2.48 ± 0.06 B	1.78 ± 0.05 A
El-Fayoum Farm	169 ± 5.3 A	5.4 ± 0.4 A	2.58 ± 0.05 A	1.79 ± 0.06 A
F-value	127**	193**	7.5**	1.28

Data are represented as means of eight samples ± S.D..
Means with the same letter for each parameter are not significantly different, otherwise they do (Duncan's multiple range test, 1955).
** Highly Significant difference ($P<0.05$).

Table (7): Muscle quality of the Nile tilapia; *Oreochromis niloticus*, collected from different aquatic habitats.

Locations	Water contents (%)	Total protein (% of wet weight)	Total lipids (% of wet weightl)	ASh (%)
River Nile	81.6 ± 1.1 A	14.6 ± 0.71 C	2.65 ± 0.37 C	2.49 ± 0.29 A
El-Abbassa Farm	78.33 ± 0.54 B	16.6 ± 0.51 B	4.11 ± 0.53 A	2.08 ± 0.13 B
El-Fayoum Farm	76.7 ± 0.42 C	18.4 ± 0.39 A	3.26 ± 0.39 B	1.98 ± 0.12 B
F-value	84.5**	95.4**	22.3**	14.8**

Data are represented as means of eight samples ± S.D..
Means with the same letter for each parameter are not significantly different, otherwise they do (Duncan's multiple range test, 1955).
** Highly Significant difference ($P<0.05$).

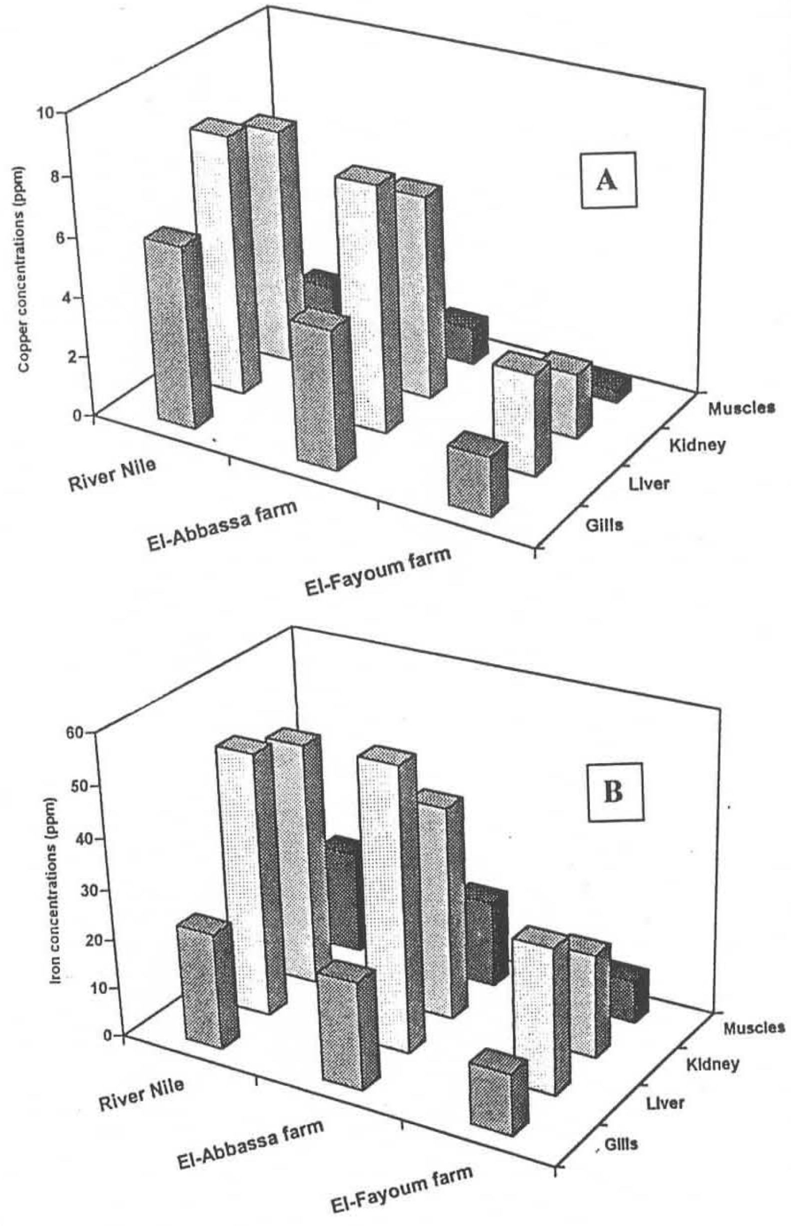

Fig.(1): Copper(A) and iron(B) concentrations in some selected organs(mg/kg dry weight) of the Nile tilapia, *Oreochromis niloticus*, collected from different aquatic habitats.

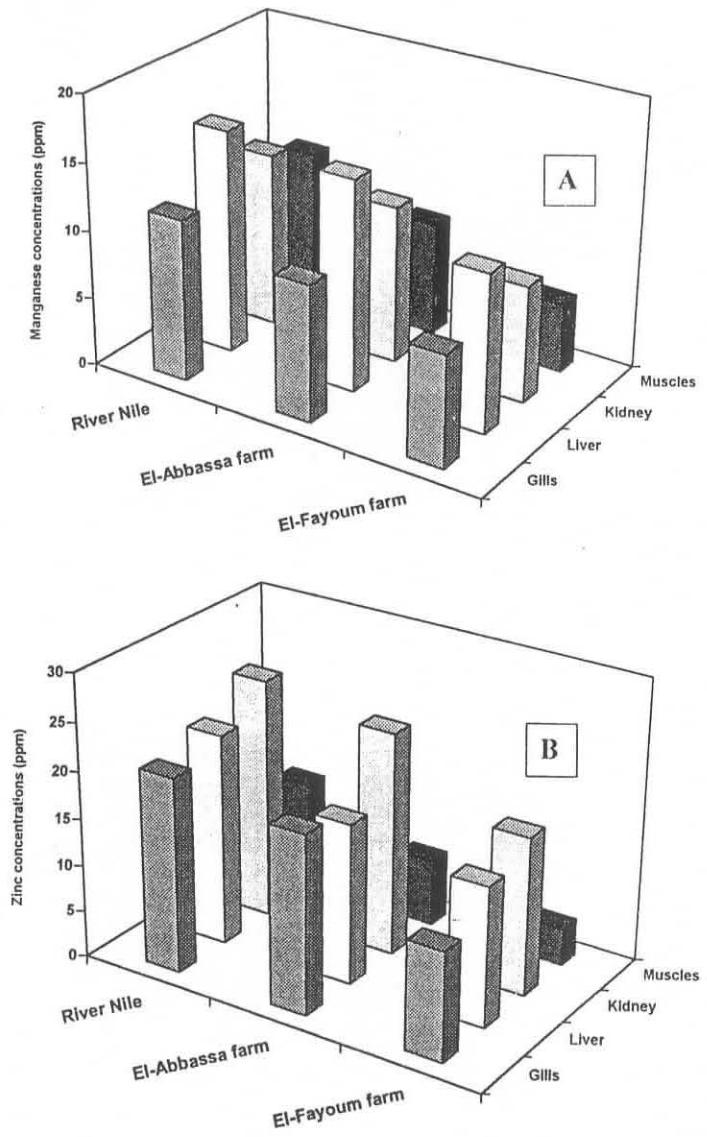

Fig.(2): Manganese (A) and Zinc (B) concentrations in some selected organs (mg / kg dry weight) of the Nile tilapia, *Oreochromis niloticus*, collected from different aquatic habitats.

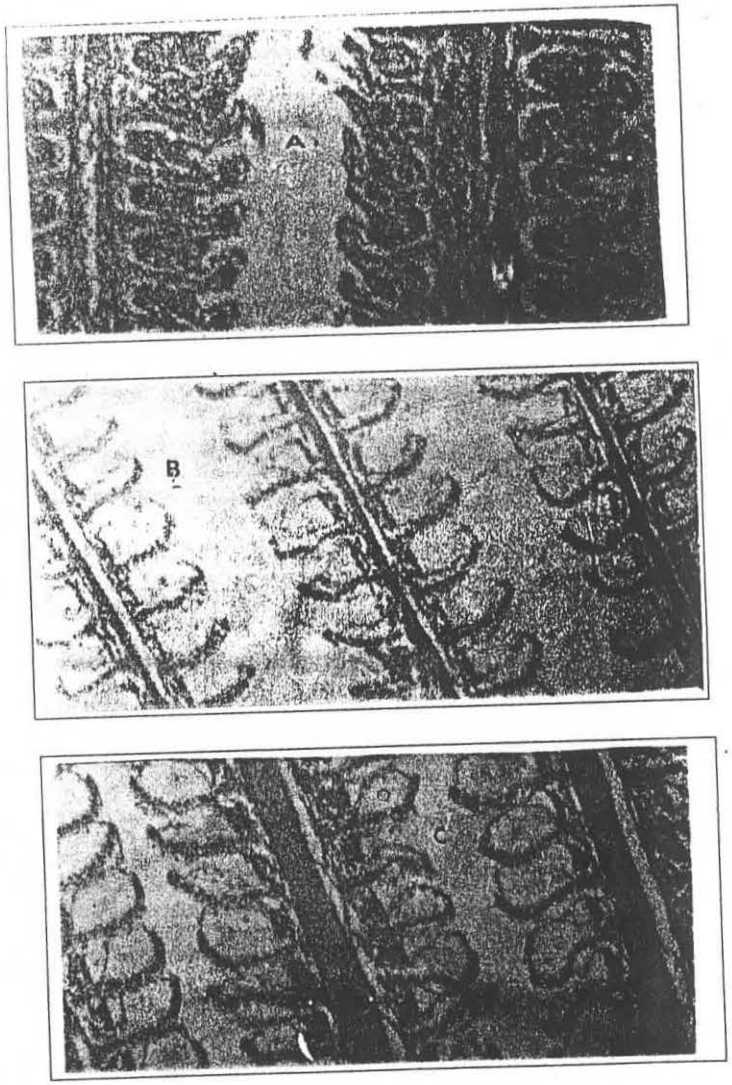

Fig.(3): Histological sections of gills of the Nile tilapia; *Oreochromis niloticus* collected from the River Nile (A); El-Abbassa Farm (B) and El-Fayoum Farm (C) (E & H) (X 250).

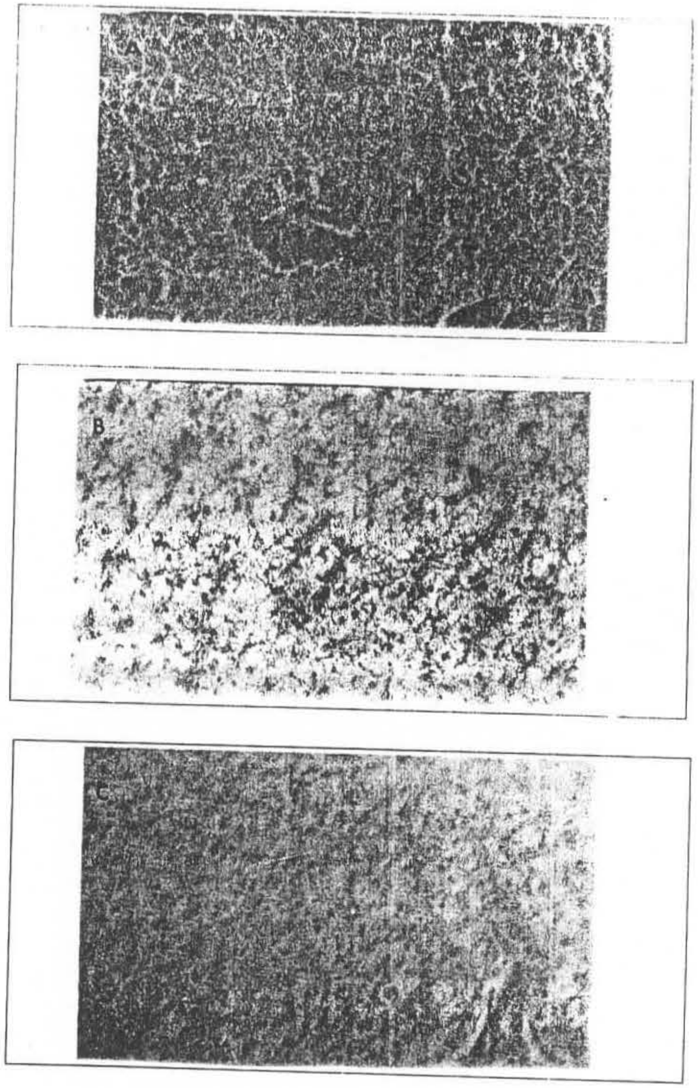

Fig.(4): Histological sections of liver of the Nile tilapia; *Oreochromis niloticus* collected from the River Nile (A); El-Abbassa Farm (B) and El-Fayoum Farm (C) (E & H) (X 250).

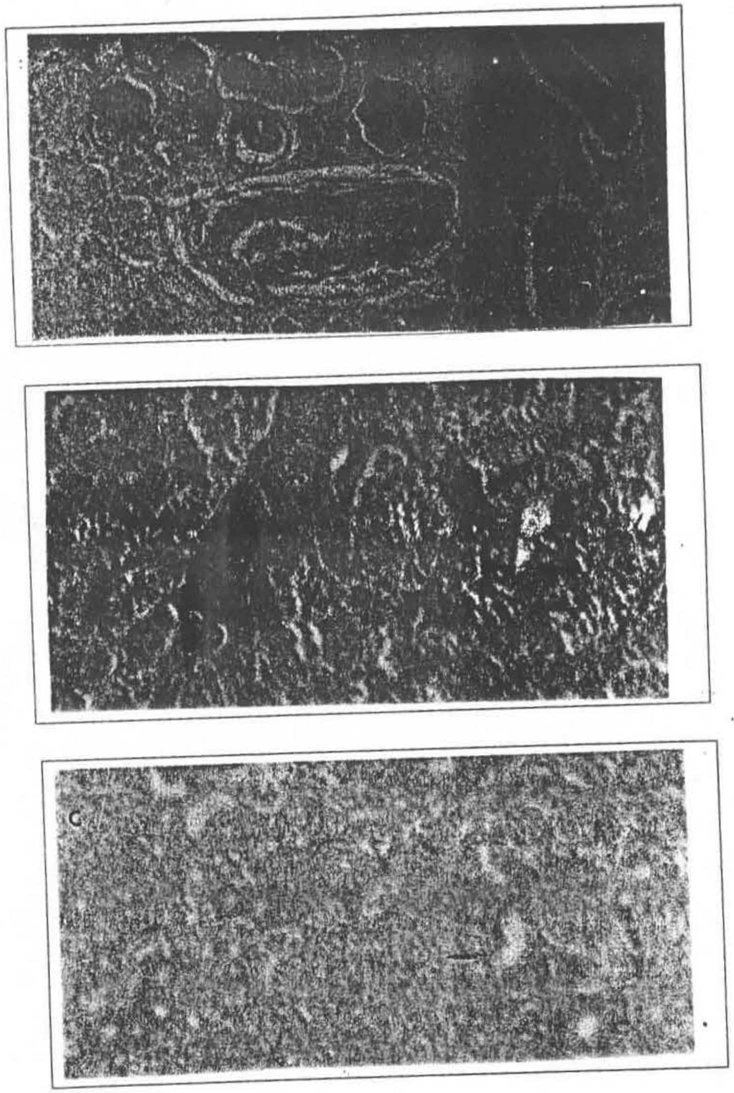

Fig.(5): Histological sections of kidneys of the Nile tilapia; *Oreochromis niloticus* collected from the River Nile (A); El-Abbassa Farm (B) and El-Fayoum Farm (C) (E & H) (X 250).

المجلة المصرية لعلم الحيوان
المجلد ٣٤ (يونيه ٢٠٠٠)

المؤتمر الثامن
(فبراير ٢٠٠٠)

دراسات بيئية وبيوكيميائية على أسماك البلطي النيلي المستزرعة فى بيئات مائية مختلفة

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تعتبر البيئة المائية من أهم العوامل التى تؤثر على حيوية وإنتاجية الأسماك. لذلك تمت دراسة تأثير جودة المياه على جودة أسماك البلطي النيلي فى عينات تم تجميعها من نهر النيل (قطاع القاهرة- ١٥ كم من المنطقة الصناعية بحلوان) ومزرعتين للأسماك إحداهما تروى بمياه عذبة (مزرعة العباسة) وأخرى بمياه شروب (مزرعة الفيوم).

وقد أظهرت الدراسة اختلافا ذا دلالة احصائية عالية فى الأكسجين الذائب ودرجة الأس الهيدروجينى والملوحة والعسر الكلى والقلوية الكلية والتوصيل الكهربائي والفسفور والنترات وبأعلى قيم لعينات مياه مزرعة الفيوم فيما عدا الأكسجين الذائب والذى ظهر بتركيز أعلى فى مياه نهر النيل عن المزارع السمكية.

وقد سجلت الدراسة تركيزا أعلى لبعض العناصر الثقيلة (حديد،نحاس،زنك ومنجنيز)فى مياه المزارع عنها فى مياه النيل باستثناء الزنك. أما بالنسبة للهائمات النباتية فقد كانت أكثر كثافة فى مياه مزرعة العباسة عنها فى مياه مزرعة الفيوم بينما كانت الهائمات الحيوانية أكثر كثافة فى مياه مزرعة الفيوم عنها فى مياه مزرعة العباسة . أما مياه النيل فإنها تعانى من فقر شديد فى كل من الهائمات النباتية والحيوانية.

وبدراسة تأثير الأنظمة البيئية المختلفة على فسيولوجية سمكة البلطي النيلي وجد نقص ملحوظ فى عدد كرات الدم الحمراء وقيم الهيماتوكريت والهيموجلوبين والدهن الكلى للمصل وزيادة ملحوظة فى عدد كرات الدم البيضاء ،وجلوكوز الدم والبروتين الكلى وانزيمات الكبد (ALT&AST) فى المصل والكرياتينين وحمض اليوريك للأسماك المجمعة من نهر النيل عن تلك المجمعة من مزارع العباسة والفيوم والتى أوضحت الدراسة تشابهاً للأسماك المجمعة منها فى قيم ثوابت الدم واختلافا فى القياسات الأخرى للمصل.

وقد أوضحت الدراسة تراكم العناصر الثقيلة فى خياشيم وكبد وكلى وعضلات أسماك مياه النيل عن أسماك المزارع بفروق عالية الدلالة والذى أدى بدوره إلى تدمير واضح فى الخياشيم وتهتك فى كبد وكلى الأسماك. بينما أظهرت تركيزات العناصر وأنسجة الأسماك المجمعة من مزرعة العباسة والفيوم نتائج طبيعية.وقد أثبت البحث بمجمل نتائجه جودة لحم الأسماك المرباة فى المياه الشروب عنها فى المياه العذبة وتلك المجمعة من نهر النيل